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## Prevention of Infectious Diseases in Athletes

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Infections in sports can be serious medical problems. They can affect individual athletes, resulting in morbidity and decreased performance [1]. They can also be spread to other athletes, putting them at risk for similar disease and complications. The sports medicine physician may face challenging issues regarding infectious diseases when dealing with teams or highly competitive athletes who have difficulties taking time off to recover. One must treat the individual sick athlete and take the necessary precautions to contain the spread of communicable disease to the surrounding team, staff, relatives, and other contacts.

The authors aim to translate recommendations in public health to practice in a sports medicine setting. Sports physicians have an opportunity to see athletes during adolescence and adulthood who might not come in for routine health maintenance except when related to their sports. Primary prevention of infectious disease, the ideal goal, deals with avoiding the development of the disease before infection occurs. Immunizations are an example of primary prevention and have been the most successful public health programs for disease prophylaxis. Secondary prevention for infection control involves prevention of spread to others. Athletes are often exposed to many different people, travel to compete in various environments locally and internationally, and engage in higher-risk activities, often in close contact with others [2]. The authors discuss the preventive strategies for infectious disease in sport, including (1) a review of immunization recommendations and prophylaxis guidelines, (2) improvements in personal hygiene and prevention of spread of infectious organisms by direct contact, (3) insect-borne disease precautions, and (4) prevention of sexually transmitted diseases (STDs). A special emphasis on immunizations focuses on pertussis, influenza, and meningococcal prophylaxis.

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## PUBLIC HEALTH, INFECTIOUS DISEASES, AND SPORTS

Public health plays an insidious role in our everyday lives to keep individuals safe from communicable diseases, accidents, environmental concerns, and countless other dangers. Programs are most successful when a disease no longer becomes a worry for the population through active prevention strategies. Much of our understanding comes from history and from recognizing the imminent dangers so we can prevent diseases from occurring the next time.

Medical reports from major athletic events provide examples of issues that can be encountered by the sports medicine physician. Mass-gathering events, such as the Olympics, highlight some of the concerns that can occur with sports and infectious diseases. International athletes compete together from countries with different endemic microorganisms and variable health care practices. For example, an outbreak of measles occurred in a Special Olympics event in St. Paul, Minnesota. The point of infection was suspected to be a track and field athlete from Argentina, resulting in measles infections in 16 individuals from 7 different states [3]. An outbreak of influenza that occurred during the 1988 Calgary Olympics was believed to have possibly affected the performances of some athletes [4]. The pneumococcal vaccine was recommended to athletes before competing in the 1992 Barcelona Olympics because of resistant *Streptococcus pneumoniae* strains endemic in Spain [5]. Medical reporting and surveillance of infections are extremely important to attempt to contain spread of disease. At the 1996 Atlanta Olympics, a priority of surveillance was to identify unusual presentations and infectious disease outbreaks to actively implement same-day medical and public health interventions [6].

It is an important responsibility of physicians to report specific infectious diseases, especially if an outbreak is suspected (Box 1) [7]. Health professionals should contact their local public health officer to determine whether other cases are occurring and what precautions need to be taken in the event of a serious outbreak. In the past few years, infections such as severe acute respiratory syndrome [8] have required the need of quarantine to help control the spread of these dangerous diseases. Health care professionals should report all clinically significant adverse events following immunization to the Vaccine Adverse Events Reporting System [9].

## ATHLETES ARE “HIGHER RISK”

The risk of disease transmission depends on the infectious agent—for example, whether it is spread by way of respiratory secretions, skin contact, or blood. In the context of infections spread by aerosol droplets, “close contact” can mean caring for or living with an infected patient or having a high likelihood of direct contact with the respiratory secretions or body fluids of an infected patient. Examples of close contact include kissing or embracing, sharing eating or drinking utensils, talking to someone within 3 ft, physical examination, and any other direct physical contact between people. Close contact does not include activities such as walking by a person or briefly sitting across from someone [10].

**Box 1: Infectious diseases designated as notifiable at the national level during 2004**

Acquired immunodeficiency syndrome (AIDS)  
Anthrax  
Botulism  
Brucellosis  
Chancroid  
*Chlamydia trachomatis*, genital infection  
Cholera  
Coccidioidomycosis  
Cryptosporidiosis  
Cryptosporidiosis  
Cyclosporiasis  
Diphtheria  
Ehrlichiosis  
    Human granulocytic  
    Human monocytic  
    Human, other or unspecified agent  
Encephalitis/meningitis, arboviral  
    California serogroup  
    Eastern equine  
    Powassan  
    St. Louis  
    Western equine  
    West Nile  
Enterohemorrhagic *Escherichia coli* (EHEC)  
    EHEC O157:H7  
    EHEC Shiga toxin-positive, serogroup non-O157  
    EHEC Shiga toxin-positive, not serogrouped  
Giardiasis  
Gonorrhea  
*Haemophilus influenzae*, invasive disease  
Hansen disease (leprosy)  
Hantavirus pulmonary syndrome  
Hemolytic uremic syndrome, postdiarrheal  
Hepatitis A, viral, acute  
Hepatitis B, viral, acute

**Box 1: (continued)**

Hepatitis B, viral, chronic

Hepatitis B, perinatal infection

Hepatitis C, acute

Hepatitis C, virus infection (past or present)

Human immunodeficiency virus (HIV) infection

Adult (age  $\geq 13$  years)

Pediatric (age  $<13$  years)

Influenza-associated pediatric mortality<sup>a</sup>

Legionellosis

Listeriosis

Lyme disease

Malaria

Measles

Meningococcal disease

Mumps

Pertussis

Plague

Poliomyelitis, paralytic

Psittacosis

Q fever

Rabies

Animal

Human

Rocky Mountain spotted fever

Rubella

Rubella, congenital syndrome

Salmonellosis

Severe acute respiratory syndrome-associated coronavirus (SARS-CoV) disease

Shigellosis

Smallpox<sup>a</sup>

Streptococcal disease, invasive, group A

Streptococcal toxic-shock syndrome

*Streptococcus pneumoniae*, invasive disease

Drug-resistant, all ages

Age  $<5$  years

Syphilis

Syphilis, congenital

**Box 1: (continued)**

Tetanus

Toxic-shock syndrome (other than streptococcal)

Trichinellosis<sup>b</sup>

Tuberculosis

Tularemia

Typhoid fever

Vancomycin-intermediate *Staphylococcus aureus* infection (VISA)<sup>c</sup>Vancomycin-resistant *Staphylococcus aureus* infection (VRSA)<sup>c</sup>

Varicella

Varicella deaths

Yellow fever

<sup>a</sup>New for 2004, as of October 4, 2004.<sup>b</sup>Formerly referred to as trichinosis.<sup>c</sup>New for 2004, as of January 1, 2004.

From Jajosky RA, Hall PA, Adams DA, et al. Summary of notifiable diseases—United States, 2004. MMWR Morb Mortal Wkly Rep 2006;53(53):1–79.

Athletes may share personal items (eg, towels, water bottles, and soap) and equipment (eg, weights). They may live in dormitories or in hotel rooms while traveling, which leads to close contact and high exposure to teammates. They participate in higher-risk activities [2,11]. Fewer athletes practice safe sex, which can lead to STDs in homosexual and in heterosexual individuals. Athletes also use more illicit drugs and alcohol, which can place them at risk of intravenous needle exposure [12,13]. Steroids, hormones, and vitamins are other substances that some athletes are injecting [14,15]. Tattoos are popular among athletes, which are another source of needle infection risk.

## IMMUNIZATIONS

Active immunization involves the administration of all or part of a microorganism or a modified product of that microorganism, such as an antigen or protein. This administration stimulates an immune response to develop protection against future exposure to the infection [16]. Although most vaccines are over 90% effective, they are not guaranteed to promote immune protection [16].

Immunizations typically involve inactivated vaccines or live, attenuated viruses. Inactivated vaccines include killed virus or bacterial proteins to stimulate one's immune system to develop antibodies to any similar virus or bacteria. More side effects are associated with the live, attenuated viruses—typically local pain and, rarely, hypersensitivity reactions to vaccine constituents. A mild febrile illness, a recent exposure to an infectious disease, pregnancy, breastfeeding, nonspecific allergies, and family history of an adverse event after immunization, including seizures, are NOT contraindications for immunization [16].

Sports medicine physicians need to consider the following indications for immunizations (Tables 1 and 2): (1) routine health maintenance; (2) catch-up immunizations for failed or missed immunizations; (3) immunizations of high risk groups (ie, splenectomy, chronic disease, immunocompromised); (4) travel to an endemic area; (5) close contact with an infected individual, or (6) recent potential exposure to an infectious agent.

When doing preparticipation physical examinations, it is sometimes assumed that athletes have received all their immunizations. Proof of immunizations is required by schools and colleges, although exceptions can be given to individuals refusing to receive immunizations. In a study surveying 69,115 Minnesota children who entered kindergarten in 1992, by 19 months of age, 73% of students had received the measles, mumps, and rubella (MMR) vaccine, and only 39% had received their fourth dose of diphtheria, tetanus, and pertussis vaccine (DTaP) [17]. Vaccination rates can vary substantially by age, race/ethnicity, and neighborhood [17]. White, non-Hispanic students usually have higher vaccination rates than children of other racial/ethnic groups. It has been estimated that 79% of whites, 76% of Hispanics, and 71% of African Americans are fully immunized [18].

Measles, Mumps, and Rubella

Although MMR vaccines have been administered for many decades and incidences of disease are presently low [7], the diseases can still occur in the adult population. Between 1986 and 1989, 6% of the measles cases occurred in college

**Table 1**  
Routine immunizations for adults recommended by the Centers for Disease Control and Prevention, October 2006–September 2007

Vaccine	Age group (y)		
	19–49	50–64	≥65
Tetanus, diphtheria, pertussis (Td/DTaP)	1-dose Td booster every 10 y Substitute 1 dose of DTaP for Td		
Human papilloma virus (HPV)	3 doses (female patients)		
Measles, mumps, rubella (MMR)	1 or 2 doses	1 dose	
Varicella	2 doses (0, 4–8 wk)	2 doses (0, 4–8 wk)	
Influenza	1 dose annually	1 dose annually	
Pneumococcal (polysaccharide)	1–2 doses		1 dose
Hepatitis A	2 doses (0, 6–12 mo or 0, 6–18 mo)		
Hepatitis B	3 doses (0, 1–2, 4–6 mo)		
Meningococcal	1 or more doses		

Data from United States Department of Health and Human Services, Centers for Disease Control and Prevention. Recommended adult immunization schedule, by vaccine and age group. Available at <http://www.cdc.gov/vaccines/recs/schedules/downloads/adult/06-07/adult-schedule-11x17.pdf>; Accessed November 30, 2006.



**Table 2**  
Catch-up immunization schedule for children aged 7 through 18 years recommended by the Centers for Disease Control and Prevention

Vaccine	Minimum interval between doses		
	Dose 1 to dose 2	Dose 2 to dose 3	Dose 3 to booster dose
Tetanus, diphtheria (Td) <sup>h</sup>	4 wk	6 mo	6 mo if first dose given at age <12 mo and current age <11 y, otherwise 5 y
Inactivated poliovirus (IPV) <sup>b,i</sup>	4 wk	4 wk	IPV <sup>b,i</sup>
Hepatitis B (HepB) <sup>c</sup>	4 wk	8 wk (and 16 wk after first dose)	
Measles, mumps, rubella (MMR) <sup>d</sup>	4 wk		
Varicella <sup>i</sup>	4 wk		

<sup>a</sup>DTaP. The fifth dose is not necessary if the fourth dose was administered after the fourth birthday.  
<sup>b</sup>IPV. For children who received an all-IPV or all-oral poliovirus (OPV) series, a fourth dose is not necessary if a third was administered at age  $\geq 4$  years. If OPV and IPV were administered as part of a series, then a total of four doses should be given, regardless of the child's current age.  
<sup>c</sup>HepB. Administer the three-dose series to all children and adolescents <19 years of age if they were not previously vaccinated.  
<sup>d</sup>MMR. The second dose of MMR is recommended routinely at age 4 to 6 years but may be administered earlier if desired.  
<sup>e</sup>Hib. Vaccine is not generally recommended for children aged  $\geq 5$  years.  
<sup>f</sup>Hib. If current age <12 months and the first 2 doses were Haemophilus b conjugate vaccine (PRP-OMP) (pedvaxHIB or ComVax [Merck]), then the third (and final) dose should be administered at age 12 to 15 months and at least 8 weeks after the second dose.  
<sup>g</sup>PCV. Vaccine is not generally recommended for children aged  $\geq 5$  years.  
<sup>h</sup>Td. Adolescent tetanus, diphtheria, and pertussis vaccine (DTaP) may be substituted for any dose in a primary catch-up series or as a booster if age appropriate for DTaP. A 5-year interval from the last Td dose is encouraged when DTaP is used as a booster dose. See ACIP recommendations for further information.  
<sup>i</sup>IPV. Vaccine is not generally recommended for persons aged  $\geq 18$  years.  
<sup>j</sup>Varicella. Administer the two-dose series to all susceptible adolescents aged  $\geq 13$  years.  
 Data from United States Department of Health and Human Services, Centers for Disease Control and Prevention. 2007 Child & Adolescent Immunization Schedules. Available at <http://www.cdc.gov/vaccines/recs/schedules/downloads/child/2007/child-schedule-color-print.pdf>; Accessed November 30, 2006.

students [19]. Enzyme-linked immunosorbent assay tests for antibodies to MMR are available to detect for immunization status [19]. In a series of 256 students, 53 (21%) were found to be seronegative to measles alone, 13 (5%) were seronegative to rubella alone, and 5 (2%) were seronegative to measles and rubella. Eighty-six percent of the individuals seronegative to measles had previously received a dose of measles vaccine. Following a second injection, conversion to seropositive status rose to 97% and 100% for measles and rubella, respectively. These data support the need for a two-dose vaccine schedule [19].

### Pneumococcal Vaccine

Pneumococcal vaccine is administered to prevent *Streptococcus pneumoniae* infections. A conjugate heptavalent is given to during the first 2 years of life. A polysaccharide vaccine is provided to high-risk individuals older than 2 years

against 23 types of *Streptococcus pneumonia* that account for 90% of invasive disease [20]. High-risk groups include patients who have asplenia, sickle cell disease, diabetes mellitus, cirrhosis, immunocompromised states, chronic cardiac or pulmonary disease, or age 65 years or older. Immunity following vaccination is successful for periods of 5 to 10 years, requiring booster injections [20].

### Hepatitis B

Hepatitis B is a blood-borne virus transmitted through sexual contact and parenteral exposure to blood and blood components [14]. Hepatitis B has a greater risk for transmission in sports than HIV. The risk of HIV transmission is estimated to be between 1 in 1 million games and 1 in 85 million games [14,21]. The risk arises if bleeding and skin exudates from an infected individual come into contact with open wounds in another athlete, particularly during contact and collision sports. There are no confirmed cases of spread of HIV through sports [14]; however, 5 out of 10 high school sumo wrestlers at one club developed hepatitis B [22]. Another case series reported on 11 of 65 American football players who developed hepatitis B over a period of 19 months [23]. Contact through open wounds, cuts, and abrasions were the suspected routes of transmission.

#### Primary prevention

Although hepatitis A is considered immunization in athletes who are traveling to endemic areas, routine vaccination for hepatitis B is recommended for all individuals after birth using single or combination vaccines [24]. A three-dose immunization schedule is typically used after 18 years of age, with injections at 0 months, 1 month, and 6 months, although there is an optional four-dose schedule [25]. The licensed vaccines have had 90% to 95% efficacy of preventing hepatitis B, with immunity lasting 15 years or longer [25]. Immunizations for hepatitis B should be checked during the preparticipation physical examination, and catch-up immunizations recommended to the individual (see Table 2). If individuals are uncertain about their immunization status, serologic testing for antibody to hepatitis B surface antigen can determine immunity.

#### Secondary prevention

When athletes are known to be infected with hepatitis B, secondary prevention includes education on personal hygiene, appropriate management of open wounds, proper use of protective equipment, safe sex practices using a condom, and avoidance of intravenous blood transmission (eg, through needle sharing and illicit drug use).

### Pertussis, Tetanus, and Polio

*Bordetella pertussis*, which is responsible for whooping cough, is a gram-negative coccobacillus transmitted by way of airborne droplets [26]. Although tetanus and polio have been controlled well with the use of vaccines [7], the rate of pertussis cases has been increasing in adolescents and adults despite routine immunizations [27]. Most cases occur in patients 10 years or older [28].

The infection is most concerning for infants because immunity is not complete until older ages. The spread to infants is typically from adults. Pertussis usually presents with nonspecific upper respiratory tract infection symptoms for 1 to 2 weeks (catarrhal stage), after which the paroxysmal and sometimes uncontrollable cough develops [26]. The cough is not necessarily always followed by the classic “whooping” sound, and pertussis should be considered with any persistent, prolonged cough.

#### *Primary prevention*

The whole-cell pertussis vaccine is estimated to be approximately 85% effective [29]. This vaccine is still recommended for use in the routine immunization of young children; however, the immunity provided begins to decline at 4 to 12 years following vaccination, which makes adolescents and adults susceptible [27]. Rare adverse reactions from the vaccine include hypotonic, hyporesponsive episodes, high fever, seizures, and anaphylaxis [26]. Two acellular vaccines have been introduced that are as effective as whole-cell vaccines and have fewer adverse reactions [30]. These vaccines are combined with tetanus toxoid and reduced diphtheria toxoid (DTaP). The Centers for Disease Control and Prevention (CDC) recommends use of these DTaP boosters rather than the tetanus-diphtheria (Td) booster starting after 11 to 12 years of age [31].

#### *Secondary prevention*

For pertussis, individuals are most contagious during the first 1 to 2 weeks during the catarrhal stage but should be considered contagious until 3 weeks after the paroxysmal stage ends or after taking antibiotics for 5 days [32]. Diagnosis of pertussis infection is best performed through polymerase chain reaction assay (sensitivity, 94%; specificity, 97%) or through direct fluorescent antibody testing (sensitivity, 52%; specificity, 98%). Nasal swab cultures (sensitivity, 15%; specificity, 100%) are routinely performed; however, they have high false negative rates and take 7 to 12 days to yield results [33]. Physicians in the United States are legally required to report cases of pertussis to state public health departments [26]. It is estimated that 80% of susceptible household contacts will be infected after close contact [26]. Antibiotic prophylaxis is recommended for close contacts of persons who have pertussis to prevent outbreaks [34]. Preferred drugs are azithromycin for 5 days, clarithromycin for 7 days, or trimethoprim-sulfamethoxazole or erythromycin for 14 days, which are similar for prophylaxis and treatment [34].

### **Influenza**

Influenza presents with constitutional symptoms of fever, chills, malaise, fatigue, and myalgia in addition to upper respiratory tract symptoms of a sore throat, cough, and rhinitis. Rarely, more serious conditions can occur, including encephalopathy, transverse myelitis, myocarditis, and pericarditis [9]. Immunogenicity is determined by hemagglutinins and neuraminidases on the virus surface. Antigenic drift can occur that can mutate the virus into different

strains. Transmission occurs by way of respiratory droplets. The virus has an incubation period of usually 2 days (range, 1–4 days), and adults are infectious from the day before symptoms begin to approximately 5 days after the illness starts [9]. Symptoms usually last a week, although less likely, symptoms can last longer than 2 weeks. These symptoms can be very disruptive for treatment and challenging for the athlete to keep training and competing. A case series of 81 students, mostly healthy adolescents at a ski school in Austria, reported a severe outbreak of influenza A, leading to an attack rate of 49%, with 69% becoming ill within 2 days of the outbreak. Two students were hospitalized with pneumonia and 1 died [35].

### *Primary prevention*

Influenza vaccines contain strains of antigenically equivalent strains of influenza similar to those annually recommended: influenza A (H3N2), influenza A (H1N1), and a B virus. Depending on the emergence and spread of new strains, other virus strains can be added to update the vaccine [9]. The efficacy of influenza vaccine is approximately 70% to 90% for individuals under age 65 years [36]. Vaccination for influenza should occur in the fall (October or November), at the beginning of the flu season (Box 2) [9]. Antibodies develop approximately 2 weeks after vaccination [9,37].

Inactivated influenza vaccine is generally appropriate for all populations requiring influenza vaccine. Three influenza vaccines were available in the United States for the 2006 to 2007 season: Fluzone (manufactured by Sanofi-Pasteur); Fluvirin (manufactured by Novartis); and Fluarix (manufactured by GlaxoSmithKline). The typical dose is 0.5 mL administered intramuscularly, usually in the deltoid muscle. Live, attenuated influenza vaccine (LAIV) is approved for use in healthy, nonpregnant individuals aged 5 to 49

### **Box 2: Indications for influenza vaccine**

1. Adults and children with chronic disorders of the cardiorespiratory system, including asthma
2. Adults and children who have chronic disease which may require regular medical follow-up or hospitalization, including immunodeficiency
3. Young children aged 6–23 months
4. Children aged 6 months to 18 years on long-term aspirin therapy and at risk for Reye's syndrome
5. Persons aged >65 years
6. Residents of nursing homes or chronic-care facilities
7. Health care workers
8. Travelers to influenza-endemic areas

*Adapted from* Smith NM, Bresee JS, Shay DK, et al. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2006;55(RR-10):1–42.

years. The LAIV is administered by way of a nasal spray once in each nostril (FluMist, manufactured by MedImmune). Individuals who have a hypersensitivity or anaphylactic reaction to components of the flu vaccine or to eggs should not be vaccinated [9].

Adults reported having a 19% reduction in severe febrile illnesses after LAIV compared with placebo [38]. Side effects from LAIV increased in adults within 7 days of immunization compared with placebo and consisted mainly of nasal congestion (44.5% versus 27.1%) and sore throat (27.8% versus 17.1%), which lasted, on average, 2 days. Less common complaints were tiredness, cough, and chills. There was no significant difference in the number of mild febrile illnesses between immunization and placebo groups [39]. Injections can be scheduled to occur at the optimum time during the athlete's competitive schedule to minimize concern about side effects.

When inactivated influenza vaccine shortages occurred in previous years, the vaccine was recommended for high-risk groups as priority; however, the general recommendation now is to offer the immunization annually to anyone who wishes to reduce the likelihood of being ill with influenza or transmitting the virus if they should become infected [9]. Although this policy cannot be directly translated into a benefit for the athlete, depending on the level of athlete, the use of the LAIV may also be beneficial to prevent lost time from sport. Influenza vaccine has been suggested for competitive athletes and essential personnel, especially before international events occurring during the influenza season [4,40].

### *Secondary prevention*

Treatment with antiviral medications can reduce the duration of uncomplicated influenza A and B illness by approximately 1 day when administered within 2 days of illness onset [41,42]. Recommended antiviral treatment should be given for 5 days [9]. Four antiviral agents are currently available: amantadine, rimantadine, zanamivir, and oseltamivir [9]. The influenza A virus, however, has become resistant to amantadine and rimantadine, which are presently not recommended to be used as first-line drugs [43]. Zanamivir (Ralenza, dry powder taken by orally inhaled route) and oseltamivir (Tamiflu, capsule or oral suspension) are neuraminidase inhibitors and can be used to treat patients and to control influenza outbreaks in closed settings. Although typically used in nursing homes, an outbreak in a dormitory may require chemoprophylaxis [9]. There are limited data to suggest that serious complications from influenza, such as lower respiratory tract infections, may be reduced [44]. The use of antiviral medications for prophylaxis of influenza is unclear and is not yet recommended for routine seasonal control [45]. The use of oseltamivir, however, has been recommended in specific cases, especially if there is high risk of spread such as household contacts and if individuals have not been immunized [46]. Oseltamivir was used to treat 36 of 188 patients, including 13 athletes during the 2002 Salt Lake City Winter Olympics, with medications given to close contacts, which was believed to limit the spread of influenza [47].

Clinical history and physical examination are still the mainstays for diagnosing influenza. Rapid swab tests are available and take approximately 30 minutes to detect the influenza virus. The tests are less sensitive (72%–95%) and specific (76%–86%) than the traditional viral cultures [48]. They have moderate sensitivities for influenza antigens and are more likely to produce false negative rather than false positive results [48,49]. Direct and indirect fluorescent antibody staining tests are also available, but they are ordered more in hospitals because they take 2 to 4 hours to obtain results [49]. Viral cultures are still the “gold standard” for confirming the presence of influenza and identifying the strains and subtypes [9].

### Meningitis

*Neisseria meningitidis* is a serious concern, especially for the adolescent and college populations. An alarming trend during the 1970s demonstrated an increase in meningitis deaths in college students, with living in dormitories being a risk factor. The disease can be spread by asymptomatic carriers. Students living in dormitories were 9 to 23 times more likely of getting infected than those living in other types of accommodations [50]. Freshmen who lived in dormitories had an elevated risk of meningococcal disease (odds ratio, 3.6; 95% confidence interval, 1.6–8.5;  $P = .003$ ) compared with other college students [51]. Aside from the risk of death, 11% to 19% of survivors of meningitis have serious sequelae such as neurologic disability, limb loss, and hearing loss [50].

### Primary prevention

Routine vaccination with meningococcal vaccine is recommended for college freshmen living in dormitories and for other populations at increased risk. The CDC Advisory Committee on Immunization Practices recommends routine vaccination of young adolescents (11–12 years old) with meningococcal vaccine (MCV4) at the preadolescent health care visit [50]. Therefore, sports medicine physicians may be faced with higher frequency of checking for meningococcal immunization status for high school and college athletes. A tetravalent conjugate vaccine (Menactra, Sanofi Pasteur) is available against *Neisseria meningitidis* isolates A, C, Y, and W-135 in a 0.5-mL single-dose vial. Over the age of 11 years, 75% of the meningococcal infections are caused by strains C, Y, or W-135 (CDC, unpublished data, 2004) [50]. Another vaccine, Menomune (Aventis Pasteur Limited), has been licensed since 1981 and has a similar immunogenicity profile to Menactra and is delivered subcutaneously as a 0.5-mL dose. Menactra and Menomune have serum bactericidal protection ranging from 89.4% and 94.4% for strain W-135 and 73.5% and 79.4% for strain Y, respectively [50]. Revaccination may be necessary for individuals at high risk after 5 years [52,53]. Common side effects with MCV4 were local pain in just over 50% of patients, followed by swelling, induration, and redness in approximately 10.8% to 17.1%. Fever was reported in 5.1% of children 18 years old or younger and in 1.5% of adults [50].

### *Secondary prevention*

Close contacts are at high risk and should be treated with chemoprophylaxis ideally within 24 hours of identifying the index patient [50]. The goal of treatment is to reduce nasopharyngeal carriage of *N meningitidis*. After more than 14 days after the onset of illness in the index patient, chemoprophylaxis is not necessary [50]. A single dose of ciprofloxacin (500 mg orally) or ceftriaxone (250 mg by intramuscular injection), or rifampin (600 mg twice a day for 2 days) is recommended for adults. Children between 1 month and 18 years old may take rifampin (10 mg/kg every 12 hours for 2 days), or ceftriaxone (125 mg intramuscularly) if younger than 15 years [50]. One dose of azithromycin (500 mg) was also shown to eradicate *N meningitidis* and may represent another treatment option [54].

### **Human Papillomavirus**

Human papillomavirus (HPV) is associated with 99% of cervical cancers and anogenital, head and neck, and nonmelanoma skin cancers. It is an STD and can be diagnosed by abnormal cervical cell changes seen on Pap smear [55]. This is a common infection, especially in sexually active adolescents and university students [56].

### *Primary prevention*

Primary prevention is now possible with two new vaccines: a bivalent vaccine against HPV types 16 and 18 and a quadravalent vaccine against types 6, 11, 16, and 18. The vaccines have a three-dose schedule: 0, 1, and 6 months (bivalent vaccine) and 0, 2, and 6 months (quadravalent vaccine). At 4.5 years, the bivalent vaccine was effective for producing a persistent antibody response against HPV 16 and 18, with more than 98% seropositivity and 96.9% effectiveness (95% confidence interval, 81.3–99.9) in reducing the number of reported abnormalities on Pap smear, colposcopy, or both [57]. Routine vaccination with three doses of quadrivalent HPV vaccine is recommended for girls 11 to 12 years old but can be started in girls as young as 9 years. Girls and women aged 13 to 26 years who have not been vaccinated previously or who have not completed the full vaccine series are recommended to receive a catch-up series. The vaccine is intended to be administered before potential exposure to HPV through sexual contact [58].

### *Secondary prevention*

Secondary prevention involves checking the affected individual's partners for signs of genital warts and other STDs. Regular cervical screen is recommended. Use of condoms and education on spread is important. HPV infection persists for life; however, the degree and duration of contagiousness is yet unknown [59].

### **Travel Immunizations**

Athletes traveling need to consider the endemic diseases in the geographic location where they are competing. They should be aware of risks of acquiring common diseases, their accommodations (urban versus rural), local foods, and

customs. Immunizations should ideally be planned 4 or more months in advance to allow for adequate time to administer vaccines (Table 3). There are many resources for information about prevention of infectious diseases for travelers (Table 4).

**Table 3**  
Recommended immunizations for travelers to developing countries<sup>a</sup>

Immunizations	Length of travel		
	Brief, <2 wk	Intermediate, 2 wk to 3 mo	Long-term residential, >3 mo
Review and complete age-appropriate childhood schedule (see text for details) DTaP, poliovirus, pneumococcal, and <i>Haemophilus influenzae</i> type b vaccines may be given at 4-wk intervals if necessary to complete the recommended schedule before departure Measles: 2 additional doses given if younger than 12 mo of age at first dose Varicella Hepatitis B <sup>b</sup>	+	+	+
Yellow fever <sup>c</sup>	+	+	+
Hepatitis A <sup>d</sup>	+	+	+
Typhoid fever <sup>e</sup>	±	+	+
Meningococcal disease <sup>f</sup>	±	±	±
Rabies <sup>g</sup>	±	+	+
Japanese encephalitis <sup>h</sup>	±	±	+

+ = recommended; ± = consider.

<sup>a</sup>See disease-specific chapters in Section 3 of the AAP *Red Book* for details: [Red Book: 2006 report of the Committee of Infectious Diseases. 27th edition. Elk Grove Village, (IL) American Academy of Pediatrics; 2006]. For further sources of information, see text.

<sup>b</sup>If insufficient time to complete 6-month primary series, accelerated series can be given (see text for details).

<sup>c</sup>For regions with endemic infection.

<sup>d</sup>Indicated for travelers to areas with intermediate or high endemic rates of HAV infection.

<sup>e</sup>Indicated for travelers who will consume food and liquids in areas of poor sanitation.

<sup>f</sup>Recommended for regions of Africa with endemic infection and during local epidemics, and required for travel to Saudi Arabia for the Hajj.

<sup>g</sup>Indicated for people with high risk of animal exposure (especially to dogs) and for travelers to countries with endemic infection.

<sup>h</sup>For regions with endemic infection. For high-risk activities in areas experiencing outbreaks, vaccine is recommended, even for brief travel.

From American Academy of Pediatrics. International travel. In: Pickering LK, editor. Red book: 2006 report of the committee on infectious diseases. 27th edition. Elk Grove Village (IL): American Academy of Pediatrics; 2006. p. 99; with permission from the American Academy of Pediatrics.



**Table 4**  
More common tick-borne diseases

Tick-borne disease	Organism	Common vector (geographic area)
Rocky Mountain spotted fever	<i>Rickettsia rickettsii</i>	Dog tick, <i>Dermacentor variabilis</i> (central, Pacific coastal, and eastern US) Rocky Mountain wood tick, <i>Dermacentor andersoni</i> (western US)
Human monocytotropic ehrlichiosis	<i>Ehrlichia chaffeensis</i>	Lone Star tick (south central US in Maryland, Arkansas, Tennessee, Oklahoma, and Missouri) [60]
Human granulocytotropic anaplasmosis	<i>Anaplasma phagocytophilum</i>	Blacklegged tick, <i>Ixodes scapularis</i> (north central US and New England) <i>Ixodes pacificus</i> (California) [75]
Lyme disease	<i>Borrelia burgdorferi</i>	<i>Ixodes scapularis</i> (eastern US in New England and mid-Atlantic states and Midwest US in Wisconsin and Minnesota) <i>Ixodes pacificus</i> (west in northern California)
Babesiosis	Parasite, <i>Babesia microti</i>	<i>Ixodes scapularis</i> (northeast of the US)

Abbreviation: US, United States.

**BUG-BORNE DISEASE PREVENTION**

**Mosquito-Borne Disease**

A number of arthropods, such as mosquitoes and ticks, can transmit diseases. Mosquito-vector diseases include West Nile virus, yellow fever virus, and dengue virus. West Nile virus, a flavivirus, has demonstrated a seasonally endemic epidemiology with geographic variation in the United States, especially in California, Arizona, and Colorado [7,61]. This disease typically presents between July and October, although cases have presented between April and December. The prevention of mosquito bites is the cornerstone of prevention. An athlete in an endemic area should wear an insect repellent such as deet (*N,N*-diethyl-m-toluamide), picaridin (KBR-3023), or oil of lemon eucalyptus (*p*-menthane-3,8 diol). Deet and permethin may be applied to the clothing [62]. If a sunscreen is used concomitantly, the insect repellent should be applied on top of this and removed at the end of the day. Long-sleeved shirts that are tucked into long pants are also useful.

**Tick-Borne Disease**

Tick-borne diseases include rickettsial diseases, Lyme disease, babesiosis, tick-borne relapsing fever, and occasionally, tularemia and Q fever (Table 5).

**Table 5**  
Suggested resources for preventing infections

Topic	Web site
Vaccines licensed for immunization and distribution in the United States	<a href="http://www.fda.gov/cber/vaccine/licvacc.htm">www.fda.gov/cber/vaccine/licvacc.htm</a>
How to store and handle vaccines	<a href="http://www.vaccineinformation.org/www.cdc.gov/nip/menus/vaccines.htm#Storage">http://www.vaccineinformation.org/www.cdc.gov/nip/menus/vaccines.htm#Storage</a>
Adult immunization schedule	<a href="http://www.cdc.gov/nip/recs/adult-schedule.htm">http://www.cdc.gov/nip/recs/adult-schedule.htm</a>
Travel information	<a href="http://www.cdc.gov/travel">www.cdc.gov/travel</a> <a href="http://www.who.int/ith">www.who.int/ith</a>
Children and adolescents immunization schedule	<a href="http://www.cdc.gov/nip/recs/child-schedule.htm">http://www.cdc.gov/nip/recs/child-schedule.htm</a>
HIV position statements	<a href="http://www.fims.org/">http://www.fims.org/</a> (International Federation of Sports Medicine) <a href="http://www.casm-acms.org/forms/statements/HIVEng.pdf">http://www.casm-acms.org/forms/statements/HIVEng.pdf</a> (Canadian Academy of Sport Medicine) <a href="http://www.amssm.org/hiv.html">http://www.amssm.org/hiv.html</a> (American Medical Society for Sports Medicine and the American Orthopaedic Society for Sports Medicine)
<i>Morbidity and Mortality Weekly Reports</i>	<a href="http://www.cdc.gov/mmwr">www.cdc.gov/mmwr</a>
Primer for physicians for preventing food-borne illnesses	<a href="http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5002a1.htm">http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5002a1.htm</a>

Web sites accessed November 3, 2006.

Certain athletes who participate in rural outdoor activities are more susceptible to tick bites. These sports include cross-country running, training in multiple sports in rural areas, and recreational outdoor sports such as fishing and hiking. Children are more at risk to tick bites.

Three more common rickettsial illnesses are Rocky Mountain spotted fever, human monocytotropic ehrlichiosis, and human granulocytotropic anaplasmosis [60]. The infectious organisms responsible for these illnesses maintain their lifecycles in mammals and ticks. Their prevalence reflects the geographic locations and the seasonality of the tick abundance. Their season is usually from April to September, but they can present throughout the year. Newer rickettsial diseases are emerging. These potentially lethal diseases are difficult to diagnose because they often mimic viral syndromes. As many as 60% to 75% of patients are initially misdiagnosed [63,64].

With Rocky Mountain spotted fever, more than 50% of cases are reported in the five states of North Carolina, South Carolina, Tennessee, Oklahoma, and Arkansas [65]. The presentation most often manifests as a sudden febrile illness with headache, myalgia, and a maculopapular rash that spreads in a centripetal pattern. *Rickettsia rickettsii* has a predilection for endothelial cells and can cause

a diffuse vasculitis and an untreated mortality of 10%. The diagnosis is based on clinical presentation, with epidemiologic, geographic, and seasonal considerations. Laboratory testing may be supportive with thrombocytopenia and mild liver enzyme elevation. Serologic testing is supportive only on a delayed basis with acute and convalescent titers. Human monocytotropic ehrlichiosis and human granulocytotropic anaplasmosis can also present with acute headache, fever, and myalgia. Laboratory evaluation often demonstrates leukopenia, thrombocytopenia, and transaminase elevation.

Common tick-borne illnesses that have been reported in the northeast United States are Lyme disease and babesiosis, which are transmitted by the tick *Ixodes scapularis* [66]. Babesiosis can cause a febrile illness and possibly life-threatening anemia and thrombocytopenia. Lyme disease is a rickettsial disease caused by *Borrelia burgdorferi*. As such, concurrent disease may be caused by the same tick bite (see Table 4).

#### *Tick-bite prevention*

There are no proven vaccines for these tick-borne illnesses, but all are preventable by careful vigilance and protection. The key to prevention is to understand the regional epidemiology and seasonality of the diseases. Vaccination for Lyme disease (LYMErix) was originally approved; however, the manufacturer took the vaccine off the market due to declining sales. There was a 49% efficacy after two doses and a 76% efficacy after three doses [67]; however, the protection diminished after 2 years.

Ticks thrive in a wooded environment and at the edge of woods with surrounding high vegetation. Ticks are uncommon in well-mowed lawns. Relative tick-free zones can be created by placing wood chips or gravel around recreational areas to separate the woods [68]. Other landscape management tips include removing clippings and leaves, keeping stone walls clean of leaves, and restricting the use of groundcover, such as pachysandra, where pets and children may play. Widening woodland trails and keeping in the center of the trail while walking may be helpful. When traveling in wooded areas, light-colored clothing is helpful to identify the tick. Long pants tucked into tightly woven socks and closed shoes minimize exposure. Deet at 10% to 25% should be applied to the skin. Permethrin may be applied only to the clothing. Clothes should be removed and cleaned and dried after exposure. The clothes dryer is effective in killing ticks. One should carefully check for ticks in the nymphal phase that may be the size of a pin head. Careful inspection should be done of the hair, ears, axilla, belly button, and legs. Children and pets should also be checked. It is also important to monitor pets that may travel in the woods and return indoors.

The technique of tick removal is critical. Tweezers with fine tips should be used close to the skin and pulled directly away. Squeezing the body may allow contamination of the disease into the host [69]. Lyme disease is not contracted until at least 24 hours of tick adherence [70]; however, ehrlichiosis may transmit in less than 24 hours. Preventive antibiotics are generally not indicated

because less than 5% of bites are Lyme infected, especially with a flat tick. After a high-risk exposure (when the tick has been engaged for more than 24 hours and is engorged), a single dose of 200 mg of doxycycline is believed to be effective [71].

## HYGIENE PRECAUTIONS AND INFECTION CONTROL

### Personal Hygiene

Most infectious diseases are spread from contact with the microorganism directly or indirectly from the infected individual. Athletes frequently interact with teammates, coaches, athletic trainers, and physicians and share equipment, water bottles, towels, and supplies. This interaction is particularly a concern, with the recent outbreaks of methicillin-resistant *Staphylococcus aureus* (MRSA) infections among sports teams [72,73]. Three categories of potential risk factors for spreading infection have been suggested: “sharing” (sharing soap/towels/water bottles with teammates), “skin injury” (cuts, abrasions), and “close contact” (locker adjacency to infected teammate, living on-campus) [74].

Good personal hygiene can help reduce colonization of bacteria. Bacterial counts can range from 5000 to 5 million colony-forming units per square centimeter on the hands [75]. Universal body fluid precautions—for example, using disposable gloves when examining the oral cavity or wounds and frequent hand washing—can reduce the risk of infection. MRSA is transmitted from an infected patient to the gloves of a health care worker in approximately 17% (9%–25%). Physicians, in particular, have a low compliance for using gloves and washing their hands [76]. Proper surgical hand washing is recommended to be 15 to 30 seconds with soap, a 30-second rinse with water, followed by complete drying with a towel. The use of rinses and gels with concentrations of 50% to 95% alcohol take 15 seconds to use and are effective at killing organisms [75]. The use of chlorhexidine soap has been useful for reducing MRSA infections.

Viruses and bacteria can exist on equipment. MRSA was found in the taping gel and whirlpool in the training facilities of a professional football team [72]. Using diluted bleach (1 part bleach in 9 parts water) to cleanse training areas and equipment is recommended [8]. Routine cleaning schedules for shared equipment should be established and recorded.

For upper respiratory tract infections, isolation of those who have had close contact with someone who has a confirmed or suspected infection, especially those who have active symptoms such as persistent fever and cough, is an effective and practical method of avoiding contact [8].

Any athlete who has a scratch, abrasion, or laceration or who has potentially infectious skin lesions such as vesicular or weeping skin lesions should be removed from play until the area can be securely covered with occlusive bandages or dressings to prevent leakage of blood or serous fluid [77]. Uniforms with fresh blood should be removed and replaced immediately after stopping any bleeding. Bleach diluted with tap water in a 1:10 ratio can be used to wash equipment that has had contact with blood or body fluid. Body substance

precautions should be taken by health care professionals at all times when treating open wounds.

### Prevention of Methicillin-Resistant *Staphylococcus Aureus*

One type of bacteria that has become more common in the hospital and a community-acquired infection is MRSA. Although contact sports such as wrestling and football have been commonly associated with MRSA spread, this infection has also been discovered in minimal-contact sports such as fencing [78]. Three factors are associated with MRSA spread in sports. First, even with sports that have minimal contact, there are often abrasions and chaffing from clothing and hot environments. Second, equipment is often shared and there is potential for transmission of bacteria. Third, many sports have sufficient skin-to-skin contact to transmit organisms. Subsequently, health care providers should strongly encourage good overall and hand hygiene in addition to covering all wounds and limiting shared equipment. It is crucial to have an ample supply of soap and water and alcohol-based hand cleansers. Athletes, staff, and coaches should be educated in proper first aid for wounds, in recognition of wounds that are potentially infected, and in seeking medical attention for lesions that have concerning signs, especially large pustules or boils.

### Prevention of Fungal Rashes

Athlete's foot, tinea pedis, is a common ailment not only during the hot summer months but also during the winter months with indoor sports. A number of prevention items include washing feet daily; drying between the toes; wearing cotton, nonsynthetic socks; wearing bathing shoes in public showers; and wearing sandals in warmer weather. Jock itch, tinea cruris, is best prevented by showering immediately after athletic endeavors and wearing cotton briefs. A good talc powder may be used for prevention of athlete's foot and jock itch. Ring worm, tinea corporis, is best prevented by avoiding contact. Contact athletes such as wrestlers should not participate until any lesions have cleared or can be safely and effectively covered.

## SEXUALLY TRANSMITTED DISEASE PREVENTION

Athletes may manifest risk-taking behavior and subsequently be at increased risk for STDs [2]. The preparticipation examination affords the opportunity for the clinician to address these concerns. The CDC has emphasized the five intervention strategies [79], which include education on sexual behavior, identification of asymptomatic individuals, diagnosis and treatment of infected individuals, counseling of sexual partners of persons who have an STD, and pre-exposure vaccination when applicable. Individuals at risk should be questioned about partners regarding number and same or opposite sex. Information about the type of sexual activity, the use of protection, and history of previous STDs should also be identified.

Preventive measures for an STD include abstinence if an individual or partner is actively infected and undergoing treatment. Pre-exposure prophylaxis is relevant in several situations. Hepatitis B vaccine is recommended in all

individuals potentially exposed to STDs. Hepatitis A vaccine is recommended for all men who have sex with men or users of illicit drugs (injectable and non-injectable). For girls and women aged 9 to 26 years, the new quadrivalent vaccine for HPV types 6, 11, 16, and 18 is recommended due to the higher associated risk of cervical cancer.

Most condoms are made of latex and are quite effective in STD prevention. In one study of partners of HIV-infected individuals, partners were 80% less likely to seroconvert than those who did not use condoms [80]. The male condom can also reduce the transmission of gonorrhea, chlamydiosis, and trichomiasis [81]. There may be some added protection against herpes simplex virus 2 and a 70% reduction of HPV transmission [82,83]. When an individual is allergic to latex, certain polyurethane condoms are likely just as effective, although they may break more readily. Conversely, natural-membrane condoms such as lambskin are too porous to be used for STD prevention. Only water-based lubricants should be used with latex condoms because oil bases will weaken the latex. The female condom is a double-ringed polyurethane sheath that is used vaginally and during anal receptive intercourse that is effective in limited trials in preventing HIV/STDs [84,85]. Spermicides and nonbarrier contraception have no role in STD prevention.

Finally, providers should encourage patients who have STDs to notify their partners. Often, this notification is pursued by the public health department. In the event of exposure to HIV by sexual exposure or needle stick, HIV prophylaxis is often undertaken and should be immediate. Prophylactic treatment usually involves the hospital infectious disease division to determine the best combination therapy.

## SUMMARY

Education is paramount in public health and in the prevention of infectious diseases. Athletes are a high-risk population often due to their increased exposure to different people and environments and, sometimes, their outgoing lifestyle behaviors. Primary prevention can be promoted through accurate immunizations; appropriate, planned health maintenance; good hygiene practices; and behavior modification to minimize high-risk activities. Secondary prevention can be achieved through vigilant surveillance for reportable illnesses, proper education and containment for reducing spread if an illness occurs, and timely prophylaxis with medications and immunizations in certain cases.

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